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DISTRIBUTION AND ABUNDANCE OF NATIVE BONNEVILLE CUTTHROAT TROUT (*ONCORHYNCHUS CLARKI UTAH*) IN SOUTHWESTERN UTAH

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ABSTRACT.—The Bonneville cutthroat trout (*Oncorhynchus clarki utah;* BCT) was once abundant throughout the Bonneville Basin. In southwestern Utah, however, only 3 local populations of the subspecies were known to exist in 1977, when conservation efforts to protect and replicate them began. By 1995 remnant populations were known in 6 streams, and replicate populations had been established in an additional 16. Populations of BCT in southwestern Utah streams were surveyed by electrofishingin 1994 and 1995 to describe the subspecies' status. Estimated densities of age-1 and older BCT ranged from 118 to 546 fish per km. Biomass estimates ranged from 8 to 64 kg per ha. Several age groups of BCT were collected at most locations. Six populations were classified as self-sustaining, 9 as expanding through natural recruitment, 6 as new, and 1 as hybridized. Overall status of BCT in southwestern Utah has improved since 1977, but conservation measures must continue to maintain a positive trend.

Key words: cutthroat trout, native, southwestern Utah, distribution, abundance, management, Sevier River, Beaver River, Virgin River.

The Bonneville cutthroat trout (Oncorhynchus clarki utah; hereafter BCT) is the only trout native to the Great Basin in Utah. Within the eastern portion of the Great Basin, this subspecies once occupied ancient Lake Bonneville and was abundant in waters throughout the Bonneville Basin. Numbers of BCT rapidly declined in the late 1800s and early 1900s as a result of habitat modifications, introduction of nonnative fishes, and overharvest (Cope 1955, Duff 1988, Behnke 1992). Widespread introductions of rainbow trout (Onchorhynchus *mykiss*) and Yellowstone cutthroat trout (*O.* c. *bouvieri*), in particular, displaced native trout from much of their former range. By 1955 it was feared that the native BCT might be extinct (Cope 1955). Behnke (1976), however, reported that a few remnant populations still existed in isolated streams in remote locations, 3 of which were in southwestern Utah: Birch Creek, a small headwater stream in the Beaver River drainage, and Reservoir and Water canyons in the Virgin River drainage. The Virgin River is part of the lower Colorado River basin and lies immediately south of the Bonneville Basin. It was uncertain whether these 2 populations were natural or introduced by early settlers (Behnke 1976, 1992). The southwestern Utah populations were restricted to <8 km of stream in 1977.

In the mid-1970s, the Bureau of Land Management developed habitat improvement plans for Birch Creek, and the U.S. Fish and Wildlife Service considered the BCT for federal listing under the Endangered Species Act (Bureau of Land Management 1976). Shortly thereafter, several additional remnant populations of BCT were reported from the Intermountain West (Hickman and Duff 1978). By 1988, 40 populations of BCT were recognized in Utah, Wyoming, and Idaho (Duff 1988).

In Utah the Division of Wildlife Resources (UDWR) began efforts to expand the range of BCT in 1977 by replicating the Birch Creek population. BCT from Birch Creek eventually were replicated in 4 additional streams. Other remnant populations from southwestern Utah were discovered in Deep Creek (Behnke 1976 Martin and Shiozawa 1982), the North Fork of North Creek (Martin and Shiozawa 1982), and Ranch Creek (this report and D. K. Shiozawa, Brigham Young University, personal communication). Populations from Reservoir and Water canyons were each replicated in 3 streams. A mixed population from Water and Reservoir canyons was established in Leeds Creek and 1 of its tributaries, Pig Creek. A mixed population from Reservoir Canyon, Water Canyon, and Birch Creek was established in Pine Creek. Fish from Pine Creek were subsequently

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introduced into Manning Meadow Reservoir to create a BCT broodstock, primarily for sport fishery management. By 1995 remnant populations of BCT were known from 6 southwestern Utah streams, and replicate populations were established in 8 other areas (Fig. 1).

Our objective is to describe the current status of "conservation populations" of BCT in southwestern Utah, defined as those which are managed to ensure the continued existence of native subspecies (Schmidt et al. 1995). Population status was described by summarizing recent data on distribution, abundance, and population structure for all known conservation populations of BCT in the Sevier, Beaver, and Virgin river drainages. Comparisons were made between recent and older survey data to describe population changes or trends. A brief review of conservation measures for BCT in southwestern Utah is also provided.

METHODS

Pure populations of BCT were identified by at least 2 independent reviews using different methods: meristic characteristics along with fish-stocking records, electrophoresis, and mitochondrial DNA analysis (Behnke 1976 and personal communication, Martin and Shiozawa 1982, Martin et al. 1985, Thompson 1987, Shiozawa and Evans 1994a, 1994b).

All known BCT populations in southwestern Utah were sampled during 1994–95 using a backpack electrofisher. Surveys were conducted when stream conditions allowed effective sampling. We avoided periods when flows were high, turbidity made visibility difficult, or streams were partially frozen. A minimum of two 161-m (0.1-mile) stations were electrofished on primary streams (defined as the highest order stream in an area that contained BCT). A minimum of 1 station was electrofished on primary stream tributaries. Stations included habitat representative of the stream or stream section. One electrofishing pass was made through a station, moving upstream, and we attempted to collect all BCT except young-of-the-year (Y-O-Y). Measurements of individual fish lengths (TL) were taken on all BCT collected. Y-O-Y were observed from midsummer through fall and were smaller than about 76 mm (TL). Y-O-Y were noted as present or absent. Also recorded was the number of larger (>76 mm TL) BCT observed but not collected. That number was then added to the number collected to estimate the minimum population of age-1 and older BCT. Previous estimates of minimum population based on 1 pass were similar to population estimates made using the removal method (Zippin 1956).

Individual fish weight was estimated using the relationship

$$\text{Log(Weight)} = -4.91367 + 2.95756\ \text{Log(Length)};$$

the model was based on data from 373 BCT from 6 small streams in southwestern Utah prior to 1994. We tested for significant differences between the populations used to calculate the length/weight model (Dunn and Clark 1974). There was a significant difference between individual regressions, but we used the pooled model to estimate weights and biomass because maximum variation between estimates from pooled and individual regressions was only 2 kg per ha.

A minimum of 10 random stream width measurements (wetted channel) were taken at each station to calculate surface area. Trout standing crop was calculated using mean weights and estimates of minimum population of age-1 and older fish.

We also electrofished outside designated sampling stations to determine the distribution (upstream and downstream range) of BCT in some streams. Reaches where BCT were observed were classified as occupied habitat. Available habitat included occupied areas as well as areas in which we thought BCT would eventually become established. Stream lengths for habitat categories were from U.S. Geological Survey 7.5-minute series topographical maps.

To describe changes and trends in BCT populations, we compared recent abundance and distribution data to past information from UDWR files. We also made some comparisons with data for nonnative rainbow trout at several locations from which they were later removed prior to establishing BCT by transplants. Survey methods used prior to 1994 were similar to those listed above. We made visual observations to supplement formal surveys at some BCT streams and reviewed related work such as collections for transplants.

We assessed the status of each surveyed population using the above data and knowledge of land-management practices and habitat quality in BCT streams. BCT populations were

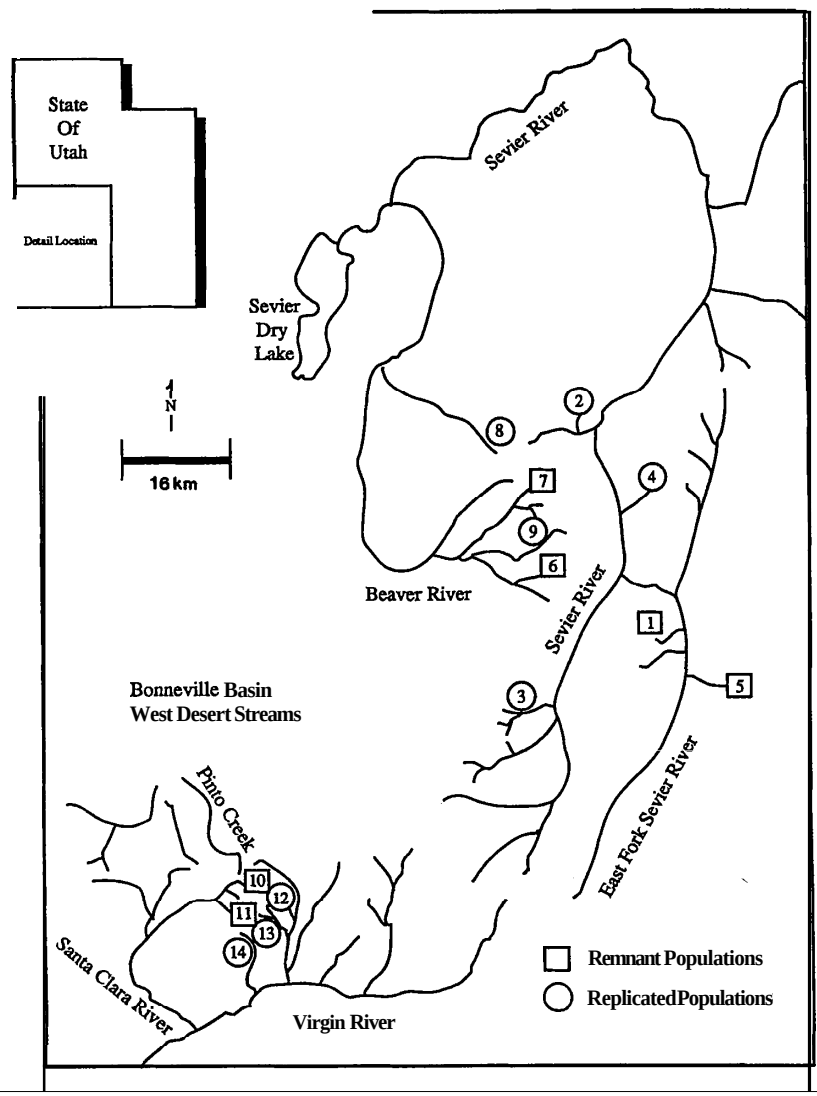

Fig. 1. Map of the Sevier, Beaver, and Virgin river drainages in southwestern Utah. Reference numbers correspond to primary streams containing Bonneville cutthroat trout populations as listed in Table 4.

classified as self-sustaining, expanding, new, or hybridized. Self-sustaining populations had multiple successive year classes and appeared distributed throughout the suitable habitat available at the time of sampling. Expanding populations showed evidence of natural recruitment but did not occupy all available habitat. Recently established populations were classified as new, and any population that showed evidence of introgression with nonnative trout was considered hybridized.

RESULTS

Estimated densities of age-1 and older BCT ranged from 118 to 546 fish per km (Table 1), and biomass ranged from 8 to 64 kg per ha. Several age groups of BCT were collected at most locations, with older fish ranging up to 305 mm TL (Fig. 2). Most fish collected were 100–250 mm TL. The highest biomass estimates for age-1 and older BCT were for Leed's Creek drainage, where they ranged from 53 to

TABLE 1. Stream lengths and abundance of Bonneville cutthroat trout in southwestern Utah, 1994–95.

Primary stream/tributary	Number of stations sampled (number in occupied habitat)	Average stream width (m)	Available km	Occupied km	Trout abundance in occupied habitat: Number per km	Number per ha	Kg per km	Kg per ha
Deep Creek	2 (2)	1.86	9.7	9.7	276	1484	9.1	49
Sam Stowe Creek[a]	3 (3)	1.43	4.8	4.8	306	2136	14.3	100
Threemile Creek	Introduction in 1994	1.31	8.8	b	—	—	—	—
Delong Creek	Introduction in 1994	—	3.4	b	—	—	—	—
Indian Hollow	Introduction in 1994	—	1.6	b	—	—	—	—
Manning Creek	Treatment in 1995	—	16.4	b	—	—	—	—
Barney Outlet	Treatment in 1995	—	2.1	b	—	—	—	—
Collins Creek	Treatment in 1995	—	2.1	b	—	—	—	—
Vale Creek	Treatment in 1995	—	1.9	b	—	—	—	—
Ranch Creek	2 (2)	1.04	11.7	4.5	171	1657	5.5	53
Birch Creek	4 (3)	1.19	8.8	6.8	160	1351	5.0	42
N. Fk. North Creek	6 (2)	2.59	8.8	3.2	214	827	9.2	36
Pole Creek	Introduction in 1995	—	4.3	b	—	—	—	—
Pine Creek	3 (3)	1.86	6.3	6.3	228	1225	5.0	27
Briggs Creek	2 (2)	1.55	1.4	1.0	124	797	5.6	36
Reservoir Canyon Creek	2 (2)	2.35	3.2	3.2	546	2336	12.0	51
Water Canyon Creek	3 (1)	1.98	3.2	0.8	118	595	1.7	8
Leap Creek	4 (2)	1.80	8.8	2.7	130	721	5.6	31
South Ash Creek	3 (2)	3.32	6.0	4.0	189	570	8.9	27
Harmon Creek	2 (2)	2.71	4.8	1.8	174	639	8.5	31
Mill Creek	2 (2)	3.11	7.4	5.1	252	807	8.6	27
Leeds Creek	3 (2)	2.71	11.3	4.8	264	973	16.3	60
Pig Creek	1 (1)	1.34	1.6	1.6		1723	7.1	53
Spirit Creek	2 (2)	1.46	3.5	1.8		1788	9.4	64
Horse Creek	Introduction in 1995	—	3.4	b		—		—

[a]Bonneville cutthroat trout hybridized with rainbow trout.
[b]Limited occupied habitat because fish were recently introduced

64 kg per ha. The lowest estimate was Water Canyon, where habitat was <1 km during dry years.

BCT densities (trout per km) were higher during recent than past samplings at 4 streams (Table 2). Recent biomass estimates were intermediate between estimates for past years at 2 [illegible] at 2 of the streams surveyed. Population data were also available for 2 streams that contained rainbow trout prior to BCT introductions (Table 3). Leap Creek had an estimated population of 360 rainbow trout per km in 1983 compared to 304 and 130 BCT per km in 1989 and 1995, respectively. Population estimates for Leeds Creek were 646 rainbow trout per km in 1980 and 193 BCT per km in 1995. Estimates of biomass for these 2 streams were also lower for cutthroat trout populations than for rainbow trout, but mean lengths for cutthroat trout were substantially greater than those recorded for rainbow trout collected earlier.

One population surveyed during 1994–95 was hybridized with rainbow trout. The BCT population in Sam Stowe Creek was established by a transplant from Birch Creek in 1977. Rainbow trout from Clear Creek migrated into Sam Stowe Creek sometime after 1984, the year of the last survey prior to 1995. Barriers that had previously prevented fish movement between Clear Creek and Sam Stowe Creek were removed by highway construction or changes in irrigation diversion structures during the last 10 yr. The hybridized BCT population in Sam Stowe Creek, incidentally, had the highest biomass recorded for any of the trout populations surveyed in 1994–95.

There are currently 57.3 km of occupied and 140.5 km of available stream habitat for BCT in southwestern Utah (Table 1). Of the populations surveyed, we classified 6 as self-sustaining, 9 as expanding, 6 as new, and 1 as hybridized (Table 4).

DISCUSSION

Many factors influenced trout densities in both remnant and transplanted BCT populations. These included habitat quality, which was often determined by land-management

TABLE 2. Current abundance (1994-95) of selected Bonneville cutthroat trout populations in southwestern Utah compared to previous years.

Population (source)	Year	Number of trout per km (number of survey stations)		
		Upper stream	Middle stream	Lower stream
Deep Creek (remnant)	1980	—	161 (1)	—
	1995	—	435 (1)	118 (1)
Birch Creek (remnant)	1970	404 (1)	—	186 (1)
	1974	385 (1)	248 (1)	—
	1975	230 (1)	342 (1)	—
	1980	161 (1)	0 (1)	0 (1)
	1987	—	335 (1)	—
	1994	155 (1)	174 (1)	149 (1)
N. Fk. North Creek (remnant)	1970	273 (1)	—	—
	1981	56 (1)	—	—
	1994	214 (2)	0 (2)	0 (2)
Reservoir Canyon (remnant)	1980	397 (1)	—	—
	1995	540 (1)	553 (1)	—
Water Canyon Creek (remnant)	1980	37 (1)	99 (1)	12 (1)
	1995	118 (1)	0 (1)	0 (1)
Sam Stowe Creek (transplant)	1980	174 (1)	0 (1)	—
	1984	422 (1)	25 (1)	—
	1995[a]	422 (1)	292 (1)	205 (1)
Pine Creek (transplant)	1982	130 (1)	75 (1)	168 (1)
	1984	—	298 (2)	248 (1)
	1994	180 (1)	230 (1)	273 (1)
Leap Creek (transplant)	1989	304 (1)	—	—
	1994	—	0 (1)	0 (2)
	1995	130 (2)	—	—

[a]Bonneville cutthroat trout hybridized with rainbow trout.

practices, and natural events such as droughts, floods, and fires. Many of the streams we surveyed were relatively small and the amount of trout habitat varied considerably with annual variations in stream flow. Much of lower Birch Creek, for example, contained marginal trout habitat that was caused by low flow and high water temperature. Surveys have been conducted 6 times on Birch Creek since 1970 (Table 2). Estimated BCT densities generally exceeded 250 fish per km, with >10 km occupied during extended periods of high water. Following droughts in 1977 and the early 1990s (Utah Climate Center 1994), BCT density was generally <175 fish per km. In 1980 the population was confined to the upper 3 km or less of stream. Changes in land management (Bureau of Land Management 1976) have since improved trout habitat in Birch Creek and reduced impacts of recent drought. Even though the latest drought was more severe and of longer duration than the 1977 drought, a healthy population existed in >6 km of stream.

Effects of drought were even more dramatic at Water Canyon, where surveys were conducted following droughts in 1977, the late 1980s, and early 1990s (Table 2). BCT densities were very low. By late summer 1989, BCT were restricted to <0.5 km of stream near the headwaters; the remainder was completely dry. Good water years occurred during the mid-1980s (Utah Climate Center 1994), and fish expanded into >3 km of stream. Formal surveys were not conducted in the mid-1980s, but we knew by our observations that BCT numbers and range had increased greatly. In fact, we collected and transplanted over 190 BCT from the lower portion of Water Canyon in 1986–1989 to establish replicate populations in Leap, Spirit, and Pig creeks. All BCT collected for transplants were taken from the lower 2 km of stream, which had been dry in 1977. During our 1995 survey BCT were still recovering from the drought that began in 1989 and were restricted to approximately 1 km of stream.

Fires, flash floods, and associated changes in water quality have also impacted BCT streams in southwestern Utah. Summer rainstorms following a 1986 wildfire in the Leeds Creek watershed severely reduced the rainbow trout

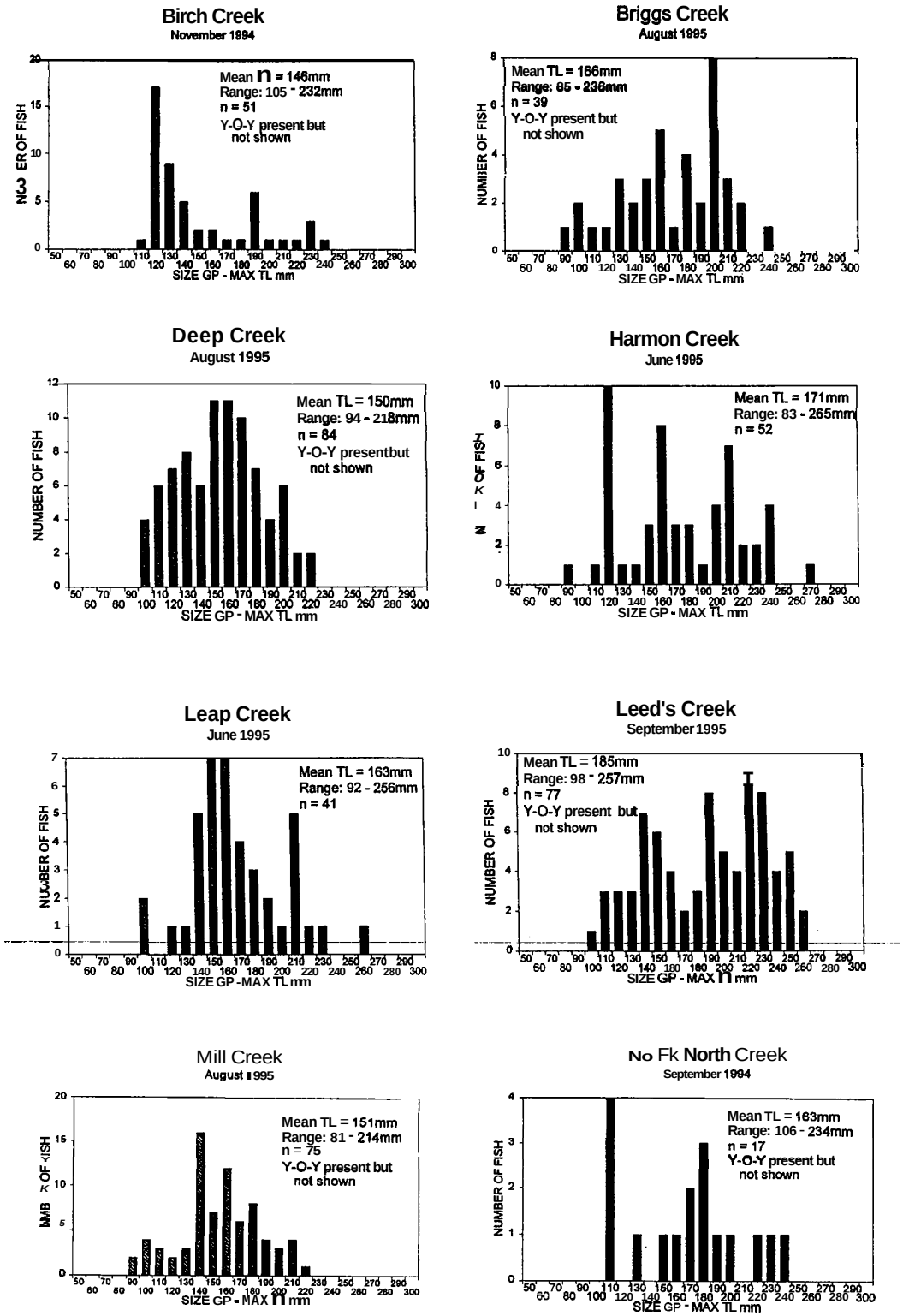

Fig. 2. Frequency histograms of total length measurements (mm) of Bonneville cutthroat trout collected from southwestern Utah streams, 1994–95.

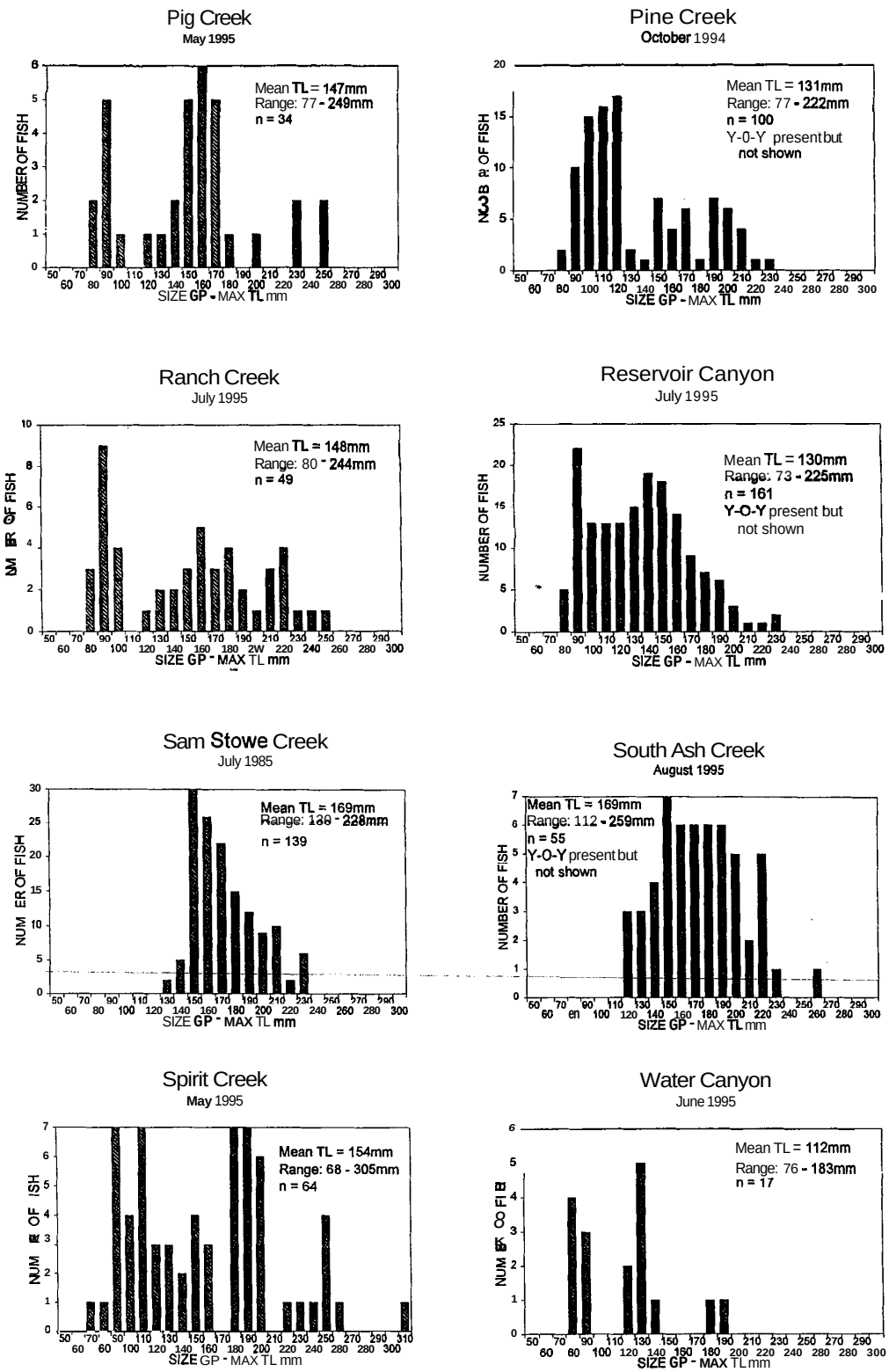

Fig. 2. Continued.

TABLE 3. Abundance, biomass, and total length of Bonneville cutthroat trout and rainbow trout in 2 southwestern Utah streams (samples were from different time periods but from the same survey locations).

Stream	Species/year	Number per km	Kg per km	Mean length (mm)	n
Leap Creek	Rainbow trout 1983	360	11.8	130	29
	Cutthroat trout 1989	304	2.5	96	25
	Cutthroat trout 1995	130	5.6	163	41
Leeds Creek	Rainbow trout 1980	646	29.6	152	52
	Cutthroat trout 1995	193	12.4	188	28

population present at that time. The few surviving trout were found in springs and tributaries. Propst et al. (1992) reported a similar phenomenon following fires for Gila trout (*O.* gilae) in small streams in New Mexico. When BCT were introduced into Leeds Creek, they were placed in more of the tributaries and farther upstream in headwater springs to reduce the chance of elimination by a future fire.

Another factor that influenced the density of BCT in replicate populations was the elapsed time between the original transplant and our sampling. Many of the replicate populations were still expanding and probably had not reached carrying capacity The number of BCT initially introduced into replicate streams and the distribution of introduction sites influenced the rate of population expansion. At Pine Creek, for example, where a relatively large number of fish were introduced at several sites, BCT were abundant throughout the stream within 4 yr. At Sam Stowe Creek, in contrast, where a smaller number of BCT were introduced in the headwaters, BCT were not present in the lower reaches after 7 yr. In all instances where BCT introductions were limited to headwater areas (Sam Stowe, Leap, South Ash, and Leeds creeks), downstream movement was slow, even when larger numbers of fish were transplanted. Within a few years after introduction, fish were abundant near areas of their original release, but they were often absent only a short distance downstream.

Use of short-term studies of fish populations to assess land-management practices or build predictive models has been criticized for a number of reasons. Platts and Nelson (1988) found that trout populations in western streams, including some cutthroat populations in the Great Basin, exhibited large annual fluctuations. House (1995) reported that a wild coastal cutthroat population varied from year to year with no apparent changes in habitat conditions. Although we were limited to a single population estimate for many of the "younger" replicate populations, we had multiple-year estimates of density and biomass for a number of populations. Also, we excluded Y-O-Y trout from our estimates as suggested by House (1995) to eliminate the variation inherent when including that age group, and we did not limit our overall rating of BCT populations to formal survey data (see Methods).

In general, the status of BCT in southwestern Utah has improved since the late 1970s when conservation efforts began. Proposed recovery plans for the greenback cutthroat trout (*O.* c. *stomias*) from Colorado's east slope included establishing a minimum of 20 populations in 50 km of stream as part of the requirements to remove the subspecies from threatened status under the Endangered Species Act (U.S. Fish and Wildlife Service 1983a). The Gila Trout Recovery Plan is more general, noting that down-listing to threatened would be considered when all known indigenous lineages are replicated in the wild (U.S. Fish and Wildlife Service 1993). The Arizona Trout (Apache Trout) (*O. apache*) Recovery Plan lists the establishment and/or maintenance of 30 discrete, self-sustaining populations as a goal for delisting (U.S. Fish and Wildlife Service 1983b). In comparison, the number of BCT populations present in southwestern Utah, which represents only a portion of that subspecies' current range, is now approaching levels listed as goals in the recovery plans for other western native trouts.

Conservation Measures

Recently, the State of Utah, U.S. Fish and Wildlife Service, U.S. Bureau of Land Management, and U.S. Forest Service have begun to develop a Conservation Agreement and a Conservation and Sportfishing Management Strategy for BCT in Utah. These agreements are

TABLE 4. Status of conservation populations of Bonneville cutthroat trout in southwestern Utah, 1995.

Reference number[a]	Drainage1 primary stream1 tributary	Population origin[b]	Year identified or transplanted	Number transplanted	Status[c]
	Sevier River drainage				
1	Deep Creek	Remnant	1982[e,f]	—	S
2	Sam Stowe Creek	BC	1977	39	H
3	Threemile Creek	BC	1994	113	N
	Delong Creek	BC	1994	30	N
	Indian Hollow	BC	1994	30	N
4	Manning Meadow Reservoir	PC	1990	714	N
5	Ranch Creek	Remnant	1995[g]		S
	Beaver River drainaged				
6	Birch Creek	Remnant	1973[f]	—	S
7	N. Fk. North Creek	Remnant	1982[e]	—	E
	Pole Creek	NFC	1995	35	N
8	Pine Creek	BC, RC, WC	1980	245	S
9	Briggs Creek	BC	1988	100	E
	Virgin River drainage				
10	Reservoir Canyon Creek	Remnant	1973[f]	—	S
11	Water Canyon Creek	Remnant	1973[f]	—	S
12	Leap Creek	WC	1986	72	E
13	South Ash Creek	RC	1986	0	E
	Harmon Creek	RC	1986	80	E
	Mill Creek	RC	1986	173	E
14	Leeds Creek	RC	1989	90	E
	Pig Creek	RC, WC	1989	60	E
	Spirit Creek	WC	1988	59	E
	Horse Creek	SP	1995	35	N

[a]Numbers refer to locations on Rgure 1.
[b]BC = Birch Creek. PC = Pine Creek, NFC = North Fork North Creek, RC = Reservoir Canyon, WC = Water Canyon, SP = Spirit Creek.
[c]S = self-sustaining, E = expanding through natural recruitment, N = new, H = hybridized.
[d]The Beaver River drainage is a major subdrainage within the Sevier River drainage.
[e]Martin and Shiozawa (1982)
[f]Behnke (1976)
[g]Present study

intended to continue the present trends to eliminate threats that would warrant BCT listing as threatened or endangered under the Endangered Species Act. Following is a brief discussion of past, and planned conservation measures for BCT in southwestern Utah.

IDENTIFYING ADDITIONAL REMNANT POPULATIONS. — Most sites in which pure populations of BCT might persist in southwestern Utah have been surveyed. A number of remaining potential locations are scheduled to be surveyed in 1996–97. Although it is possible that unknown populations may be discovered, it is unlikely that many more will be found.

HABITAT PROTECTION/ENHANCEMENT.—Habitat protection and enhancement has been an integral part of the conservation work for BCT in southwestern Utah since 1976. Efforts to improve or protect habitat for remnant and replicated BCT populations have included changes in land-management practices (grazing, road closures, etc.), construction of in-stream structures to create trout habitat or stabilize stream channels, and construction of migration barriers to prevent invasion of nonnative trout into waters containing BCT. All but 3 of the BCT streams in southwestern Utah are presently designated for "emphasis on fish habitat improvement" or "intensive riparian" management according to U.S. Forest Service Land and Resource Management Plans, or are located in the Pine Valley Mountains Wilderness Area.

REPLICATING REMNANT POPULATIONS.—Work to replicate remnant BCT populations in southwestern Utah began in 1977 and continues today. Currently, plans for future work include replicating the BCT populations in Deep and Ranch creeks and restoring the hybridized population in Sam Stowe Creek to pure BCT.

CONTROL OF NONNATIVE FISH.—The stocking of nonnative cutthroat trout has been discontinued in the Sevier, Beaver, and Virgin river drainages. Chemical treatments with

rotenone and migration barriers have been used to remove and/or restrict the movement of nonnative trout in southwestern Utah BCT streams.

BROODSTOCK DEVELOPMENT/SPORTFISHERY MANAGEMENT.—A wild broodstock of southwestern Utah BCT has been established in Manning Meadow Reservoir, Piute County. In 1996 over 100,000 eggs were collected from this broodstock, which is a mixture of BCT from 3 of the remnant populations in the area. Fish produced from the broodstock are used primarily to maintain sportfishing populations of BCT in southwestern Utah where it is currently impossible to maintain conservation populations because of the presence of nonnative trout and the inability to completely remove them.

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